Iranian Journal of Veterinary Science and Technology

Received: 2022- Apr- 02
Accepted after revision: 2022- Jun- 10
Published online: 2022- Jun- 14

REVIEW ARTICLE

DOI: 10.22067/ijvst.2022.76034.1131

A review on *Babesia* spp. and tick vectors in animals in Iran

Gholamreza Razmi

Department of Pathobiology, Faculty of Veterinary Medicine, Ferdowsi University of Mashhad, Mashhad, Iran

ABSTRACT

Babesiosis is an important tick-borne disease that affects a wide range of domestic and wild animals and occasionally humans in tropical and subtropical countries. So far, More than 100 different *Babesia* species have been identified in animals. Iran is one of the largest countries in the Middle East. The existence of two chains of mountains namely Zagros and Alborz has provided a number of climatic variations with different flora and fauna. These different climatic zones in Iran are potentially favorable for a large variety of tick vectors transmitting blood pathogen protozoa like *Babesia* spp. and *Theileria* spp. in animals. In the last decade, many molecular studies have been performed to identify *Babesia* spp. and tick vectors in different parts of Iran. This review article aims to provide useful information about the history, characters, geographical distribution, and prevalence of *Babesia* species and their related tick vectors in animals in Iran.

Keywords

Babesia spp., tick, animal, Iran

Number of Figures: 1
Number of Tables: 5
Number of References:: 87
Number of Pages: 10

Corresponding author:
Gholamreza Razmi
Email: razmi@um.ac.ir
Tel: +98 (51)3878-8944

Introduction

Babesiosis is an important tick-borne disease in domestic and wild animals. The causative agent and vectors for this disease are *Babesia* spp. and Ixodid ticks, respectively [1]. *Babesia* species live and multiply as 'piroplasms' in erythrocytes of the vertebrate host, and in contrast to erythrocytic stages of Plasmodium do not contain pigment [2]. The female tick usually is infected by ingesting protozoa in the blood meal and transmitting them to new hosts as sporozoites in the tick's saliva of the next generation, larvae, nymphs, and adults. The main clinical signs of babesiosis are fever, hemoglobinuria, anemia, and icterus [2]. Babesiosis has a wide geographical distribution in temperate, tropical, and subtropical regions. Iran is located in the western Palearctic countries with a high diversity of hard ticks [3] that could act as a vector for *Babesia* spp. in animals [3]. Advances in molecular biology methods have led to changes in the identification of *Babesia* species and their vectors in the world. Many molecular studies have been conducted on *Babesia* spp. identification in domestic animals in Iran from 1998 to 2015. Based on these results, two systematic reviews were also published about babesiosis in sheep, goats, cattle, and horses [4, 5]. This review provides useful information about the history, characters, geographical distribution, and prevalence of *Babesia* species, and their related tick vectors in animals in Iran.

History of Babesia

Babesia, also called *Nuttallia*, is an apicomplexan parasite that infects red blood cells and is transmitted by hard ticks. It was discovered in the red blood cells of cattle by the Romanian bacteriologist Victor Babes in 1888. He later observed a similar organism in sheep blood [6]. Five years later, Smith and Kilbourne showed the presence of an intraerythrocytic parasite in dairy cattle with Texas cattle fever, a disease that had long stricken cattle ranchers in the southern USA [7]. They were given the name *Pyrosoma bygeminum*, and showed that ticks play a major role in the transmission of this disease. This was the first description of an arthropod-transmitted, pathogen of vertebrates. Starcovici chose the name *Babesia* for these organisms in 1893 [8]. Lignieres described two forms of *Babesia* as *B. bigemina* and *B. bovis* in cattle in Argentina in 1903 [9]. In Iran, Delpy identified B. ovis in sheep for the first time in 1936 [10]. The first human babesiosis was reported in a splenectomized Yugoslavian farmer in 1957. After the initial case in Europe, a case caused by B. microti was diagnosed in a splenectomized patient from California, USA, in 1966. *Babesia crassa* as a large *Babesia* species was isolated for the first time in the world from an Iranian sheep in 1981 [13].

Taxonomy, transmission, and morphology

The genus *Babesia* belongs to the phylum *Apicomplexa*, and the family *Babesiidae*. *Babesia* is a relatively piriform, round, or oval parasite; the apical complex contains a polar ring, rhoptries, and subpellicular tubules. Micronemes and conoids are present in some stages and in some species [14]. Based on the merozoite size and comparison with erythrocyte radius, *Babesia* spp. are divided into large and small groups. The lengths of small and large *Babesia* are 1.0 to 2.5 µm and 2.5 to 5.0 µm, respectively. The morphometric method has no clear genetic basis, because the size and morphology of *Babesia* spp. may be changed during the asexual stage within red blood cells or when infects a non-specific host [15, 16]. So far, over 100 *Babesia* species have been identified in vertebrate hosts. Of those, eighteen species have been found to cause babesiosis in domestic mammals, including pigs, horses, cattle, sheep, goats, cats, and dogs. Most *Babesia* species have been reported in rodents, cattle, and carnivores (Table 1).

Life cycle

The life cycle of *Babesia* spp. consists of at least the asexual and sexual stages of reproduction that occur within the vertebrate host and tick vector, respectively. The sporozoites of the tick's salivary glands are generally transmitted to the vertebrate host 2-3 days after tick attachment. The sporozoites change to merozoites and enter red blood cells and divide by binary fission into new merozoites. Infected erythrocytes eventually rupture and release organisms that invade and multiply within other red blood cells. Some of the merozoites become pre-gametocytes that cannot be distinguished by a light microscope. When the tick vectors ingest the infected blood of the vertebrate host, the merozoites are microscopically detectable in the tick's gut after 10 hours [16]. The pre-gametocytes develop into gametocytes and begin to form ray bodies at the anterior of the piroplasm. The ray bodies form gametes and fuse to produce a motile zygote termed ookinete, which enters the gut epithelium cells. The ookinete starts meiotic division, resulting in many kinetes productions. At this stage, the kinetes migrate via hemolymph to different tick tissues such as ovarian cells. The infection of eggs leads to transovarial transmission. Some kinetes enter the salivary gland cells where a large multinuclear sporont is finally formed, giving rise to thousands of small sporozoites, which are injected during the feeding act and lead to transstadial transmission (Figure 1) [17, 18].

Babesia spp. infection in domestic animals in Iran

Cattle

Table 1.
Different *Babesia* species and tick vectors with geographical distribution in domestic animals [1]

Host	Species	Morphology	Tick vector	Distribution
Cattle	*B. bovis*	Small	Boophilus,Rhipicephalus	Africa, America, Asia, Australia, Europe
	B. Bigemina	Large	Boophilus,Rhipicephalus	Africa, America, Asia, Australia, Europe
	B. major	Large	Haemaphysalis	Asia, Europe
	B. occultans	Large	Hyalomma	Africa
	B. ovata	Large	Haemaphysalis	Asia
	B. divergens	Large	Ixodes,	Europe
	B. sp. Kashi	Large	Hyalomma	China
Buffalo	*B. orientalis*	Small	Rhipicephalus	Asia
	B. bovis	Small	Boophilus,Rhipicephalus	Asia, America
	B. bigemina	Large	Boophilus,Rhipicephalus	Asia, America
Horse, Donkey	*B. equi*	Small		Asia, Europe, America
	B. caballi	Large	Dermacentor, Hyalomma, Rhipicephalus	Asia, Europe, America
Pig	*B. trautammani*		Rhipicephalus	Africa, Europe
Sheep, Goat	*B. ovis*	Small	Rhipicephalus	Africa, Asia, Europe
	B. motasi	Large	Haemaphysalis	Africa, Asia, Europe
	B. crassa	Small	Unknown	Asia
Dog	*B. vogeli*	Large	Rhipicephalus sanguineus	Africa, America, Asia, Australia, Europe
	B. conradae	Small		America
	B. gibsoni	Small	Haemaphysalis longicornis, Rhipicephalus	Africa, America, Asia, Australia, Europe
	B. rossi	Large	Haemaphysalis	South Africa
	B. canis	Large	Dermacentor	Europe
Cat	*B. felis*	Small	Unknow	South Africa
	B. cati		Unknow	India

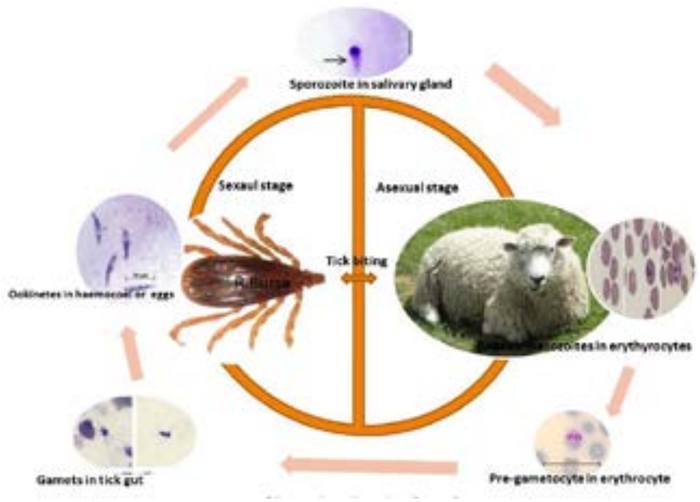

Figure 1.
The life cycle of *Babesia ovis* [1].

In Iran, the main species of *Babesia* in cattle are *B. bigemina* and *B. bovis* [19]. The first outbreak of babesiosis due to *B. bovis* was reported from a dairy farm in the Rasht area [20]. *B. bovis* localizes near the margin of the erythrocyte and is clearly smaller than B. bigemina and larger than *Theileria annulata*. The shape of *B. bovis* is ring form or ovoid. The erythrocytic stage of *B. bigemina* is large, round, oval, or pear-shaped and fills the whole erythrocyte when divided [17]. Few studies have been performed on bovine babesiosis compared to ovine babesiosis in Iran. It seems that *B. bovis* and *B. bigemina* are more common in cattle in western and northwestern Iran (Table 2). Among Ixodid ticks, *B. annulatus*, *R. Bursa*, and *R. sanguineous* could be the vector for *Babesia* spp. in dairy cattle [23, 24]. The large *B. occultance* was recently reported from two cattle in the Miandoab area by molecular methods [27].

Table 2.
Reported *Babesia* species and related tick vectors in cattle in Iran

Year	*Babesia* species	Tick vector	Province or Area	Prevalence	Diagnostic methods	References
1977	*B. bovis*	*B. annulatus*	Rasht	-	Microscopic examination	20
2012	B. bigemina	-	Tabriz	-	Microscopic examination, PCR	21
2012	B. bigemina		Kurdestan	21%	Microscopic examination	22
2012	*Babesia* spp.	*R.sanguineus* and *R. bursa*	*Kurdestan and West Azarbijan*		PCR	23
2017	B. bigemina B. bovis	B.annulatus R.sanguienus R.bursa	Urmia	42%	Microscopic examination, PCR	24
2020	B.bigemina B.bovis	-	East and West Azarbijan	25.49%	Microscopic examination, PCR	25
2020	B. bigemina B. bovis	-	Mazandaran	33.33%	PCR	26
2021	B. occultans	-	Miandoab	-	Microscopic examination, PCR	27

Sheep and goats

Three *Babesia* species including *B. ovis, B. motasi,* and *B. crassa* have been reported in infected sheep and goats in Iran (Table 3). *Babesia ovis* is a small round piroplasm, situated usually at the periphery of the red blood cells of infected sheep [17]. This species is widespread in almost all parts of Iran [28, 29]. *Babesia motasi*, as a large species is less prevalent in Iran [30]. *Babesia ovis* is high pathogenic and causes anemia and hemoglobinuria, while *B. motasi* appears moderately virulent [31]. *Babesia crassa* is a large species that was isolated from an Iranian sheep. It is characterized by an oval tetrad form in infected erythrocytes. The protozoon appears to be nonpathogenic to intact sheep and goats [13]. The outbreaks of ovine babesiosis are recorded in sheep and goats at the age of 6- 12 months each year [32-33]. Potential vectors for *B. ovis* could be *R. bursa, R. sanguineous,* and *R. turanicus* [35, 36]

Horse and donkey

Babesia equi and *B. cablli* were reported from horses in different areas of Iran (Table 4). Studies have shown that *B. equi* is more prevalent than *B. caballi* in Iranian horses and donkeys. The presence of *B. caballi* and *T. equi* was confirmed in 1940 by microscopic and molecular examination [54]. A few case reports of babesiosis due to *B. caballi* and *B. equi* have been published on horses in different parts of Iran from 1994 to 2000 [55-58]. In a study, *B. equi* infection was determined in donkeys of North Khorasan province by microscopic and molecular methods [67]. The name of *B. equi* has recently been changed to *Theileria equi,* because the sporozoites of *T. equi* first evade the lymphocytes and multiply by schizogony. After rupture of infected lymphocytes, the released merozytes enter the red blood cells and change to rounded, amoeboid, and a Maltese cross-shaped phenotype [2]. The vectors of *T. equi* could be *Hyalomma* spp. and also *Rhipicephalus* spp.. The eggs of these ticks were not infected with ookinetes to indicate transovarial transmission [17]. The merozoites of *B. caballi* are large and pear-shaped. They are produced by binary fission. *Babesia* infections are always detected in the eggs of tick vectors that could be transmitted to larvae in the next generation [17].

Table 3.
Reported Babesia species and related tick vectors in sheep and goats in Iran

Year	*Babesia* species	Tick vector	Province or Area	Prevalence	Diagnostic methods	References
1936	*B. ovis*	-	-	-	Microscopic examination	10
1966	B. motasi	-	West of Iran	-	Microscopic examination	32
1981	B. crassa	-	-	-	Microscopic examination	13
1998	*B. ovis*	-	Caspian sea, Mountainous Persian gulf Desert climates	15.93% *58.81%* *12.04%* *13.22%*	Serology	34
2002	B. ovis B. motasi	R.sangueineus Hy.marginatum	Mashhad	*24.6%* o.5%	Microscopic examination	35
2003	B. ovis B. motasi	-	Mashhad	*14%, 0.5%*	Microscopic examination	36
2006	B. ovis		Khouzestan	*47.5%*	Serology	37
2006	B. ovis B. motasi	-		-	Microscopic examination, PCR	38
2007	B.ovis	R.bursa R.sangueinus, R.turanicus			PCR	39
2008	B. ovis	-			PCR	40
2010	B. ovis		Different areas of Iran	*24.6%*	Microscopic examination, PCR	41
2012	B. ovis	-	-	-	Reverse line blot	42
2013	B. ovis	-	Tabriz	*14%*	PCR	43
2013	B. ovis		Dargaz, Kalat	*0.99%*	Microscopic examination, PCR	44
2013	B. ovis B. motasi	-	Mazandarn province	*5%*	Microscopic examination, PCR	45
2014	B. ovis	*R. turanicus, Hya. marginatum*	North khorsan province		Microscopic examination, PCR	46
2014	B. ovis	R. bursa	West Azarbijana	*16.7%*	Microscopic examination, PCR	47
2017	B. ovis	D. niveus| D. marginatus	Ardabil		PCR	48
2017	*B. ovis*	-	Lorestan		PCR	49
2017	B. ovis	R. sanguienus Hya. suspense	Gonbad Kavoos, Marvaeh tapaeh	-	PCR	50
2018	*B. ovis*		East azerbijan	*11.04%*	PCR	51
2020	*B. ovis*		Baneh	*86%*	PCR	52
2020	*B. ovis* *B. motasi*	-	Tonkabon, Ramsar	*6%*	PCR	53

Table 4.
Reported *Babesia* species and related tick vectors in horses and donkeys in Iran

Year	*Babesia* species	Tick vector	Province or Area	Prevalence	Diagnostic methods	References
2000	*B. cabali*	-	Fars province	-	Microscopic examination	57
2000	B. cabali, B. equi	-	Mashhad	-	Microscopic examination	58
2013	B.cabali, B.equi		North Khorasan Province	2%, 48%	Seology	59
2014	B. equi	*Hya. excavatum, Rh. bursa*	North Khorasan Province	45%	Microscopic examination, serology , PCR	60
2014	*B. cabali*		North Khorasan Province	4.8%	Microscopic examination, Serology	61
2014	*B. cabali, B. equi*		Urmia area	2.08%, 26%	Microscopic examination, PCR	62
2014	*B. equi*	-	Khuzestan Province	28.5%	PCR	63
2014	B. equi		Yazd area	4.7%, 22.8%	Microscopic examination, PCR	64
2014	B. equi	-	Mianeh area	4.1%	Microscopic examination	65
2015	B. equi	-	Ahvaz area		Microscopic examination,PCR	66
2015	B. equi	-	North Khorasan Province	3.77%, 50.94%	Microscopic examination,PCR	67
2016	B. equi		Piranshar area	9.6%,96%	Microscopic examination , PCR	68
2017	B. equi, B. caballi	-	Isfhan, Sharekord	-	PCR	69
2017	B. equi	-	Kurdistan	1.61%	Microscopic examination , PCR	70
2018	B. equi	-	West Azarbijan	3.2%, 27.7%	Microscopic examination , PCR	71

Dog

For the first time, *Babesia* canis, and *B. gibsoni* were reported in the blood smear of splenectomized dogs and foxes from the north of Iran in 1973 [72]. Further study was shown that the isolated strain is mild and does not produce clinical signs in experimentally infected dogs. Many studies have reported the large *Babesia* spp. in dogs of different parts of Iran (Table 5). *Babesia canis* as a large *Babesia* has three subspecies, *B. canis vogeli*, *B. canis rossi*, and *B. canis canis*. They are different in genotype, geographic distribution, pathogenicity, and vector-specificity [73].

Table 5.
Reported *Babesia* species in dogs in Iran

Year	*Babesia* species	Tick vector	Province or Area	Prevalence	Diagnostic methods	References
1973	*Babesia canis* *Babesia gibsoni*	-	Mazandaran Province	0.64%	Microscopic examination	72
2012	B. canis		Shiraz	-	PCR	74
2013	B. canis		Khousestan Province	3.75%	Microscopic examination	75
2014	B. canis		Charmahal Bakhtiri	7.5%	PCR	76
2016	*B. gibsoni*		Kerman province	5%	PCR	77
2020	*B. canis vogeli*		Shariar	-	PCR	78
2021	*B. canis vogeli*		Hamadan	4%	PCR	79
2022	B. canis canis		Tehran	-	PCR	80

Babesia gibsoni, B. conradea, and *Theileria annae* are termed small canine *Babesia*. Among different hard tick species, it has been reported that *R. sanguineous* could act as a vector for *B. vogeli* and *B. canis*, and *Haemaphysalis spp.* as a veorct for *B. rossi* and *B. gibsoni* [73].

Camel

So far, a specific *Babesia* species has not been reported in camels worldwide. Based on molecular methods, *Babesia* species related to cattle and horses have been found in camels [81]. *Babesia caballi* and *T. equi* have been detected in camels in Iran [82-84].

Rodents

Babesia microti, a species of rodent origin, has been recognized as an agent of human babesiosis in the world [1]. There are a few reports about the presence of *Babesia microti* in Iran [85-87].

Conclusion

This review presented a comprehensive summary of research findings on the identification, prevalence, and distribution of *Babesia* species and their related vectors in domestic animals in Iran. In the last decade, many molecular studies have been performed to identify *Babesia* spp. and tick vectors in different parts of Iran. However, there is no information about *Babesia* infection in cats and wild animals. Further molecular and experimental methods will be needed to better understand the epidemiology of *Babesia* species and their related tick vectors in domestic and wild animals.

Competing Interests

The authors declare that they have no conflict of interest.

References

1. Schnittger L, Rodriguez AE, Florin-Christensen M, Morrison DA. Babesia: a world emerging. Infect Genet Evol. 2012; 12(8):1788-809.

2. Service MW, editor. The Encyclopedia of Arthropod-Transmitted Infections. Liverpool: CABI Publishing; 2001.

3. Hosseini-Chegeni A, Tavakoli M, Telmadarraiy Z. The updated list of ticks [Acari: Ixodidae & Argasidae] occurring in Iran with a key to the identification of species.Sys Appl Acarol. 2019; 24(11): 2133-2166.

4. Kalani H, Fakhar M, Pagheh A. An overview on present situation babesiosis and theileriosis and their distribution of ticks in Iran. Iran J Med Microbiol. 2012; 5 (4):59-71

5. Haghi MM, Etemadifar F, Fakhar M. et al. Status of babesiosis among domestic herbivores in Iran: a systematic review and meta-analysis. Parasitol Res. 2017; 116 (4): 1101–1109

6. Babes V. Sur l'hemoglobinurie bacterienne du boeuf. Comptes rendushebdomadaires des seances de l'Academie des Sciences, Paris 1888; 107: 692–694.

7. Smith T, Kilborne F L. Smith T, Kilborne FL. Investigations into the nature, causation and prevention of southern cattle fever. In: Ninth annual report of the Bureau of Animal Industry for the year 1892. Washington DC: Government Printing Office; 1893.

8. Uilenberg G. Babesia--a historical overview. Veterinary parasitology, 2006; 138(1-2), 3–10. doi: 10.1016/j.vetpar.2006.01.035

9. Hoyte H M. Initial development of infectious Babesia bigemina. Australian Vet. J. 1961; 8: 462– 466.

10. Delpy LP. Agent's pathogens observe en Iran dans le sang des animaux domestiques. Note prélimi¬naire. Bulletin de la Société de Pathologie Exotique.1936; 29, 157–161. [In French]

11. Skrablo Z, Deanovic Z. Piroplasmosis in man; report of a case. Doc Med Georg Trop. 1957 Mar; 9(1):11-6. PMID: 13427667.

12. Scholtens RG, Braff EH, Heal GR, Gleason N. A case of babesiosis in man in the United States. Am. J. Trop. Med. Hyg. 1968; 17: 810–813.

13. Hasherni-Fesharki R, Uilenberg G. Babesia crassa. [Sporozoa, Babesiidae] of domestic sheep in Iran, Veterinary Quarterly, 1981; 3(1): 1-8.

14. Levine N D. The Protozoan Phylum Apicomplexa. Florida: Boca Raton, CRC Press, 1988.

15. Chauvin A, Moreau E, Bonnet S, Plantard O, Malandrin L. Babesia and its hosts: adaptation to long-lasting interactions as a way to achieve efficient transmission. Vet Res. 2009; 40(2):37.

16. Homer MJ, Aguilar-Delfin I, Telford SR III, Krause PJ, Persing DH. Babesiosis. Clin Microbiol Rev. 2000; 13:451–69.

17. Melhorn H. Parasitic animals: Diagnosis, Treatment and prevention. Switzerland: Springer Nature. 2016.

18. Jalovecka M, Sojka D, Ascencio M, Schnittger L. Babesia Life Cycle - When Phylogeny Meets Biology. Trends Parasitol. 2019; 35(5):356-368.

19. Rafyi A, Alavi A, Maghami G. Etat actuel de nos connaissances sur les Maladies parasitaires les plus importantes en Iran et Lutte contre ces Maladies. Archi Razi Instit. 1971; 23(1):45-9.

20. Hashemi-Fesharaki R, Amjadi AR. An outbreak of Babesia bovis in cattle andits control. Arch. Inst. Razi, 1977; 29:83-86.

21. Javadi Mamagani AR, Shahbazi A, Fallah E, Khanmohammadi M, Nematollahi A, Ashrafi Helan J, Fartashvand M, Mahami-Oskouei M. A case report of mixed infection in Holstein cattle with Theileria annulata and Babesia bigemina in one of the Tabriz traditional dairies. J Comp Pathol.2012; 9(3): 759-764.

22. Fakhar M, Hajihasani A, Maroufi S. et al. An epidemiological survey on bovine and ovine babesiosis in Kurdistan Province, western Iran. Trop Anim Health Prod .2012; 44, 319–322.

23. Tavassoli M, Tabatabaei M, Mohammadi M, Esmaeilnejad B, Mohamadpour H. PCR-based Detection of Babesia spp.. Infection in Collected Ticks from Cattle in West and North-West of Iran. J Arthropod Borne Dis. 2013; 7(2):132-138.

24. Rajabi S, Esmaeilnejad B, Tavassoli M. A molecular study on Babesia spp.. in cattle and ticks in West-Azerbaijan province, Iran. Vet Res Forum. 2017; 8(4):299-306.

25. Ghadimipour R, Noaman V, Taghizadeh M. Prevalence and risk factors of Babesia bovis and Babesia bigemina infection in cattle in northwestern Iran. Vet Clan Pathos, 2020; 14 (54): 155-168.

26. Nouri Vahedi N, Noaman V. The Molecular Study of Babesia Species in the Cattles of Mazandaran Province. J Anim Biology.2020; 12(3): 81-90.

27. Noaman V, Ghadimipour R, Nabavi R. First report of Babesia occultans in two symptomatic cows in Iran. Parasitol Res. 2021; 120: 1915–1919.

28. Anwar M.Geographical distribution of protozoan blood parasites of domestic animals in Iran. Bull.Off.interEpizoot. 1974; 81:793-898.

29. Rak H'.Tick-borne diseases and their vector in Iran. Endinburg: University press.1978

30.Hooshmand –Rad P. Blood protozoan diseases inn ruminants. Bull off Int Epiz .1974; 81:779-792.

31.Hashemi-Fesharki R. Tick-borne diseases of sheep and goats and their related vectors in Iran. Parassitologia. 1997; 39(2):115-117.

32. Rafyi A, Maghami G.Contribution of an l'etude desquelques parasites du sang du mouton de la chevre en Iran ET dans les pays voisins. Bull.Off.interEpizoot. 1966; 65:1769-1783

33. Arshadi M. Control of tick borne diseases in Iran. Bull.Off. interEpizoot. 1976; 86:45-53.

34. Tavassoli M, Rahbari S. Seroepidemiological survey of Babesia ovis in sheep at different geographical regions of Iran. J Fac Vet Med Uni Teh. 1998; 53(3/4):55-9.

35. Razmi GR, Naghibi A, Aslani MR, Fathivand M, Dastjerdi K. An epidemiological study on ovine babesiosis in the Mashhad suburb area, province of Khorasan, Iran. Vet Parasitol. 2002;; 108(2):109-15.

36. Razmi GR, Naghibi A, Aslani MR, Dastjerdi K, Hossieni H. An epidemiological study on Babesia infection in small ruminants in Mashhad suburb, Khorasan province, Iran. Small Rum Res. 2003; 50(1-2):39-44

37. Hashemzadeh Farhang H, Nabavi L, Seyfiabad Shapouri MR, Rahbari S, Azizi F. Development of an ELISA technique for the detection of Babesia ovis and serological survey of the parasite in Khouzestan province, Southern Iran. Iranian J Vet Res. 2006; 7(2):53-8.

38. Shayan P, Rahbari S. Simultaneous differentiation between Theileria spp.. and Babesia spp.. on stained blood smear using PCR. Parasitol Res. 2005; 97(4):281-6.

39. Shayan P, Hooshmand E, Rahbari S, Nabian S. Determination of Rhipicephalus spp.. as vectors for Babesia ovis in Iran. Parasitol Res. 2007; 101(4):1029-33.

40. Shayan P, Hooshmand E, Nabian S, Rahbari S. Biometrical and genetical characterization of large Babesia ovis in Iran. Parasitol Res. 2008 Jun; 103(1):217-21.

41. Dehkordi ZS, Zakeri S, Nabian S, Bahonar A, Ghasemi F, Noorollahi F, Rahbari S. Molecular and biomorphometrical identification of ovine babesiosis in Iran. Iran J Parasitol. 2010; 5(4):21-30

42. Ranjbar-Bahadori S, Eckert B, Omidian Z, Shirazi NS, Shayan P. Babesia ovis as the main causative agent of sheep babesiosis in Iran. Parasitol Res. 2012; 110(4):1531-6.

43. Shahbazi A, Fallah E, Mamagani AJ, Khanmohammadi M, Nematollahi A, Bazmani A. Identification of Babesia species in sheep isolated from villages of East Azerbaijan by Semi-nested PCR. J Pure Appl Microbiol. 2013; 7:201-5.

44. Razmi G, Pourhosseini M, Yaghfouri S, Rashidi A, Seidabadi M. Molecular detection of Theileria spp.. and Babesia spp.. in sheep and ixodid ticks from the northeast of Iran. J Parasitol. 2013; 99(1):77-81.

45. Mottavlihaghi M, Fakhar M, Sharif M, Paghe A, Sharbatkhori M, Tavakoli R, Gholami S. Molecular identification of ovine Babesia spp.. in north of Iran.Res.Mol Med.2013; 1(1):35-39.

46. Seidabadi M, Razmi G, Naghibi A. Molecular detection of Babesia spp. in sheep and vector ticks in North Khorasan province, Iran. Iranian J Vet Med. 2014; 8(1):35-39.

47. Esmaeilnejad B, Tavassoli M, Asri-Rezaei S, Dalir-Naghadeh B, Mardani K, Golabi M, Arjmand J, Kazemnia A, Jalilzadeh G. Determination of prevalence and risk factors of infection with Babesia ovis in small ruminants from West Azerbaijan Province, Iran by polymerase chain reaction. J Arthropod Borne Dis. 2015; 9(2):246-252.

48. Shabazi GR, Matine S, Shabazi R, Babapour A, Ahmadi G, Bageri Y. First detection of Babesia ovis in Dermacentor spp. in Ardabil area, northwest of Iran. J Vector Borne Dis. 2017; 54(3):277.

49. Naderi A, Nayebzadeh H, Gholami S. Detection of Babesia infection among human, goats and sheep using microscopic and molecular methods in the city of Kuhdasht in Lorestan Province, West of Iran.J Parasit Dis. 2017; 41(3):837-842.

50. Bekloo A J, Bakhshi H, Soufizadeh A, Sedaghat M M, Bekloo R J, Ramzgouyan M R, Chegeni A H, Faghihi F, and Telmadarraiy Z. Ticks circulate Anaplasma, Ehrlichia, and Babesia and Theileria parasites in North of Iran. Vet Parasitol. 2017; 248 (15): 21–24.

51. Bazmani A, Abolhooshyar A, Imani-Baran A, Akbari H. Semi-nested polymerase chain reaction-based detection of Babesia spp.. in small ruminants from Northwest of Iran. Vet World 2018; 11(3):268-273.

52. Habibi G, Sepahvand-Mohammadi E, Afshari A, Bozorgi S. Molecular detection of Theileria spp.. and Babesia ovis infection in sheep in Baneh, Iran. Arch Razi Inst. 2020; 75(2):289-296.

53. Razmi GR, Pourhosseiniserani M. Molecular detection of Theileria spp.. and Babesia spp.. in sheep and vector ticks in Ramsar and Tonkabon areas of Mazandaran province, Iran. J Vet Parasitol. 2020; 34(2):82-88.

54. Sazmand A, Bahari A, Papi S, Otranto D. Parasitic diseases of equids in Iran [1931-2020]: a literature review. Parasit Vectors. 2020 Nov 19; 13(1):586.

55. Oryan A, Aslani MR, Rezakhani A, Maleki M, Shad-Del FA. Babesia caballi and associated pathologic lesions in a horse. Equine practice 1994; 16:33-37.

56. Nouri A, Lotfalizadeh S, Report a case of equine babesiosis in Ahwaz. J Fac Vet Med Uni Teh.1994; 48; 49-54.-

57. Aslani MR. A case report of Babesia caballi infection in a foal. J Appl Anim Res 2000 ; 17(2):253-6.

58. Seifi HA, Mohri M, Sardari K. A mixed infection of Babesia equi and Babesia caballi in a racing colt: A report from Iran. J Equine Vet Sci. 2000; 20(12):858-60

59. Abedi V, Razmi G, Seifi H, Naghibi A. Seroprevalence of Theileria equi and Babesia caballi infection in Turkoman breed horses in Iran. Iran J Vet Sci Tec. 2013; 5(2):45-52.

60. Abedi V, Razmi G, Seifi H, Naghibi A. Molecular and serological detection of Theileria equi and Babesia caballi infection in horses and ixodid ticks in Iran. Tick Tick Borne Dis. 2014 ; 5(3):239-44.

61. Abedi V, Razmi GR, Seifi HA, Naghibi A. Seroprevalence of Babesia caballi Infection in Horses in the North Khorasan Province of. J Vet Sci Med Diag. 2014; 3(1).

62. Malekifard F, Tavassoli M, Yakhchali M, Darvishzadeh R. Detection of Theileria equi and Babesia caballi using microscopic and molecular methods in horses in suburb of Urmia, Iran. Vet Res Forum. 2014; 5(2):129-33.

63. Bahrami S, Ghadrdan AR, Pourmahdi Borujeni M, Vafayi Salarpur M. Epidemiology of Theileria equi in Persian Arab horses from Iran. Vet Med 2014; 59(9):409-411.

64. Bahrami S, Ghadrdan AR, Mirabdollahi SM, Fayed MR. Diagnosis of subclinical equine theileriosis in center of Iran using parasitological and molecular methods. Trop Biomed. 2014; 31(1):110-117.

65. Davoodi J. Identification of Babesia species and vector ticks in equine in Meyaneh area. Scientific J Vet Adv. 2014; 3(3):48-50.

66. Razi JM, Rocky A, Shahriari A, Ghadrdani MA, Hamidinejat H, Jolodar A, Pourmahamd BM. Hematological parameters and clinical signs associated with equine piroplasmosis in purebred Arabian horses of Ahvaz. Iran Vet J. 2015; 11(1): 65 -75.

67. Abedi V, Razmi G, Seifi H, Naghibi A. Molecular detection of equine piroplasms in donkeys [Equus asinus] in North Khorasan province, Iran. Iran J Vet Res. 2015; 16(2):202-204.

68. Habibi G, Esmaeilnia K, Hablolvarid MH, Afshari A, Zamen M, Bozorgi S. Microscopic and Molecular Detection of Theileria [Babesia] Equi Infection in Equids of Kurdistan Province, Iran. Iran J Parasitol. 2016; 11(1):86-90.

69. Hosseini R,Taktazhafshejani T, Khamesipour F. Molecular detection of Theileria equi and Babesia caballi infections in horses by PCR method in Iran. Kafkas Univ Vet Fak Derg. 2017; 23:161-164.

70. Kakekhani S, Rahbari S, Madani R, Bokaei S. Molecular and microscopic detection of Theileria equi and Babesia caballi in horses in Kurdestan Province, Iran. Arch Razi Inst. 2017; 72(1):51-5.

71. Ebrahimi M, Adinehbeigi K, Hamidinejat H, Tabandeh MR. Molecular characterization of Theileria equi infection in horse populations belonging to West Azerbaijan, Iran: insights into the importance of Equine Merozoite Antigen [EMA]-1 in its diagnosis. Ann Parasitol. 2018; 64(1):21-27.

72. Niak A, Anwar M, Khatibi S. Canine babesiosis in Iran. Trop Anim Hlth Prod. 1973 Sep; 5(3):200-1.

73. Green CE. Infectous diseases of dog and cat. 4th, Ed .Missouri: Elsevier 2013.

74. Bigdeli M, Rafie SM, Namavari MM, Jamshidi S. Report of Theileria annulata and Babesia canis infections in dogs. Comp Clin Pathol. 2012; 21(3):375-377.

75. Razijalali M, Mosallanejad B, Avizeh R, Alborzi AR, Hamidinejat H, Taghipour R. Babesia infection in urban and ru-

ral dogs in Ahvaz district, Southwest of Iran. Arch Razi Inst 2013; 68 (1): 37-42.

76. Raki A, Doosti A, Shahrani M. Detection of Babesia canis in the blood samples of dogs in Iran by PCR method. Int J Bio Sci. 2014; 4(1):118-24

77. Akhtardanesh BA, Saberi ME, Nurollahifard SR, Aghazamani MA. Molecular detection of Babesia spp.. in tick-infested dogs in southeastern Iran. J Dis Glob Health. 2016; 8(2):72-7.

78. Habibi G, Imani A, Afshari A, Bozorgi S. Detection and molecular characterization of Babesia canis vogeli and Theileria annulata in free-ranging dogs and ticks from Shahriar County, Tehran Province, Iran. Iran J Parasitol. 2020; 15(3):321-331.

79. Iatta R, Sazmand A, Nguyen VL, Nemati F, Ayaz MM, Bahiraei Z, Zafari S, Giannico A, Greco G, Dantas-Torres F, Otranto D. Vector-borne pathogens in dogs of different regions of Iran and Pakistan. Parasitol Res. 2021; 120(12):4219-4228.

80. Ghasemzade M, Esmaeilnejad B, Asri-Rezaei S, Hadian M. Molecular identification of Babesia canis canis genotype A in a dog from Iran. Vet Med Sci. 2022; 8(1):21-25.

81. Sazmand A, Joachim A. Parasitic diseases of camels in Iran [1931-2017] - a literature review. Parasite. 2017; 24:21.

82. Khamesipour F, Doosti A, Koohi A, Chehelgerdi M, Mokhtari-Farsani A, Chengula AA. Determination of the presence of Babesia species in blood samples of cattle, camel and sheep in Iran by PCR. Arch Biol Sci. 2015; 67(1):83-90.

83. Bahrami S, Tabandeh MR, Tafreshi AR. Prevalence and molecular identification of piroplasmids in Iranian dromedaries [Camelus dromedarius]. J Zoo Wild Med. 2017; 48(4):1026-30.

84. Mirahmadi H, Ghaderi A, Barani S, Alijani E, Mehravaran A, Shafiei R. Prevalence of camel babesiosis in southeast of Iran. Veterinary Medicine and Science. 2022;8(1) :343-8..doi. org/10.1002/vms3.666.

85. Mohebali M. The first report of Babesia microti in rodents captured in Meshkin-Shahr, Iran. Iran J Pub Hlth. 1997; 26(3–4):83–85.

86. Hamedi Y, Heydari M, Soleymani Ahmadi M, Intestinal and blood parasites of brown rats in Bandar Abbas. Hormozgan Med J. 2003; 7(3):123–127.

87. Shahbazi A, Aboualsoltani N, Bazmani A, Khanmohammadi M, Aboualsoltani F, Fallah E. Parasitological and molecular study of Babesia microti in rodents of Sarab district. J Pure Appl Microbiol. 2014; 8(3):2241-2244.

How to cite this article

Razmi Gh. A review on *Babesia* spp. and tick vectors in animals in Iran. Iran J Vet Sci Technol. 2022; 14(2): 1-10.
DOI: https://doi.org/ 10.22067/ijvst.2022.76034.1131
URL: https://ijvst.um.ac.ir/article_42489.html